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**Front cover:** Yellow-tailed Black Cockatoo *Calyptorhynchus funereus.* Photo Sue Forster.

# Sassafras Creek Nature Conservation Reserve in the Dandenong Ranges functions as a wildlife corridor for regionally significant fauna

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**Abstract**
The Sassafras Creek Nature Conservation Reserve forms a linear wildlife corridor in the Dandenong Ranges, representing an important link between the Sherbrooke and Olinda units of the Dandenong Ranges National Park, while on a broad scale linking with the Yarra Ranges via Woori Yallock Creek and the upper reaches of the Yarra River. This study presents findings from a fauna survey undertaken in the reserve with motion-sensing cameras, in which regionally significant fauna such as the Mountain Brushtail Possum, Superb Lyrebird and Long-nosed Bandicoot were detected in the corridor, providing evidence that the area is functional for regionally significant fauna. The sites surveyed included an urban environment, typical of land adjacent to the reserve; revegetated areas restored by local environmental groups; and largely unmodified remnant Cool Temperate Rainforest with few or no environmental weeds present. Site-level contrasts between these habitat types are explored (*The Victorian Naturalist* 139(1), 2022, 4–13)

**Keywords:** wildlife corridor, peri-urban wildlife, fauna survey, habitat restoration

## Introduction

Wildlife corridors are areas of linear vegetation connecting larger patches of wildlife habitat that facilitate the movement of biota through an unsuitable or inhospitable surrounding 'matrix'. These features of a landscape may serve a variety of purposes, including wildlife conservation, recreation and amenity and the provision of ecosystem services, thus conferring environmental and social value upon a landscape (Bennett 1998). Existing protected areas of habitat may cause the confinement of biotic communities and result in negative impacts on genetic fitness (Haddad *et al.* 2003). To solve this issue, biota need to be able to migrate through a connected system (Dilkina *et al.* 2017). Thus, maintaining wildlife corridors is becoming increasingly recognised as a conservation strategy to enhance the persistence of fauna populations (Chetkiewicz *et al.* 2006). Wildlife corridors may serve as permanent living space for some species, while providing a pathway for movement through degraded and often urbanised or agricultural environments for others. There are numerous aspects that may enhance the function of a corridor. The landscape context of a corridor has been found to determine the number of species using the passageway; for example, a corridor that connects gullies and ridges is likely to be used by a greater suite of species (Lindenmayer and Nix 1993). Habitat quality and the degree of disturbance from introduced species and weeds may impair the effectiveness of a wildlife corridor. Furthermore, a corridor consisting of remnant vegetation is likely to be of heightened value to wildlife when located in urban areas, especially where natural features (e.g., large old trees, fallen timber) remain.

In urban landscapes, riparian zones (vegetated land alongside a body of water) often represent natural wildlife corridors that have remained undeveloped and, therefore, contain relatively natural vegetation. Riparian vegetation is a key element along creek corridors, providing a range of ecosystem services, such as biofiltration, flood mitigation and erosion control (Cole *et al.* 2020). Riparian buffer strips help to maintain a healthy stream and form a protective barrier to surrounding human activity, which may in turn create a healthy ecosystem (Saunders *et al.* 2002).

In the 'peri-urban' landscape of the Dandenong Ranges, on the fringe of Melbourne, there is little supporting research concerning whether

vegetated areas in riparian corridors are an effective means of supporting wildlife populations. Sassafras Creek Nature Conservation Reserve (SCNCR) is a linear reserve situated on the south-eastern slopes of the Dandenong Ranges (Fig. 1). The reserve area measures 46 ha in total, with 27 ha along the Sassafras Creek Corridor. Sassafras Creek flows from the Sassafras township through Kallista, becoming the Woori-Yallock Creek south of Monbulk. Vegetation along the corridor comprises Wet Forest and Cool Temperate Rainforest in its upper reaches, with Damp Forest becoming dominant downstream from Monbulk (Department of Land, Water and Planning [DELWP] 2020b). In the 1850s, logging occurred throughout the townships of Sassafras, Kallista and Olinda, with the harvested timber sent to Melbourne for construction. Timber harvesting continued in some areas until the 1960s, representing a period of significant landscape change that greatly modified the natural landscape (Friends of Sherbrooke Forest 2000).

The community-based volunteer group Friends of Sassafras Creek (FOSC) actively works to preserve, protect and improve biodiversity values in SCNCR. FOSC has three key aims: 1) to work to improve biodiversity and habitat in the reserve; 2) to educate the community about the local environment; and 3) to form strong working relationships with relevant management agencies. Members of the group gather for monthly working bees, with a smaller subgroup meeting fortnightly to complete weeding and revegetation work. The group is highly engaged with the environmental community, maintaining strong relationships with other local volunteer groups along the creek corridor. This network facilitates coordinated conservation actions across the landscape. FOSC works in a systematic way to control weeds and revegetate areas in the corridor; however, further information is required on the effectiveness of this work in fostering biodiversity along the corridor.

This survey aimed to 1) provide a current camera-trapping fauna survey to record elusive

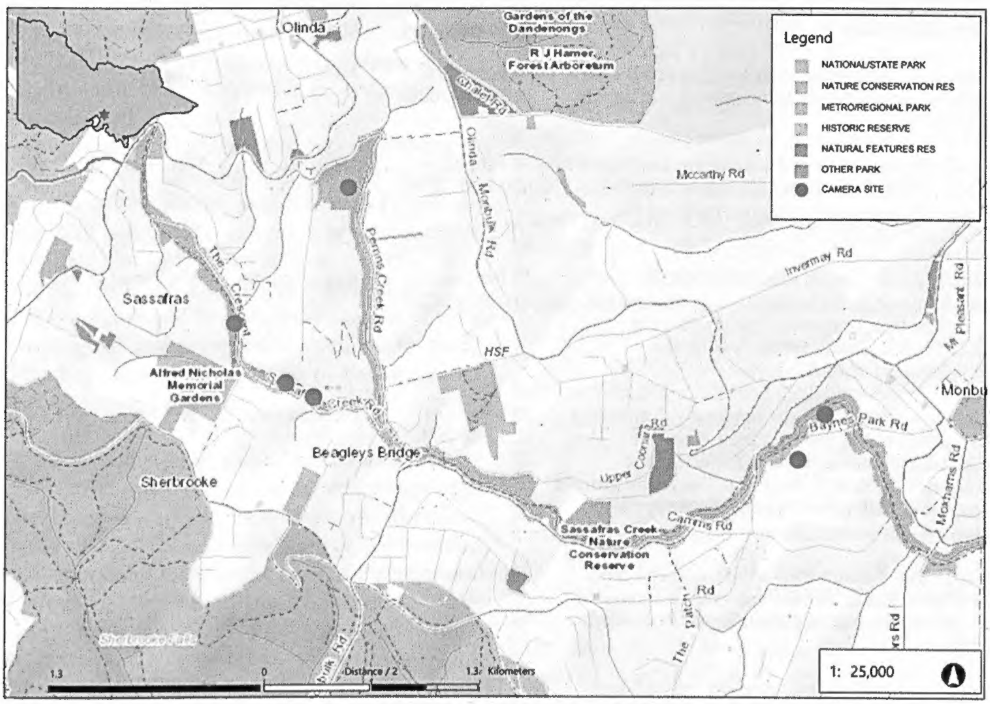


Fig. 1. Map of the Sassafras Creek Nature Conservation Reserve in the Dandenong Ranges. The red dots signify the camera sites.

and rare species that may still be present in the Dandenong Ranges, and 2) compare the relative activity levels of fauna across areas of varying habitat quality within and directly adjoining SCNCR. It was expected that sites within areas of undisturbed habitat should have more recorded native species than those situated within recently revegetated sites and those dominated by environmental weeds. The findings were assessed to gauge whether the creek corridor is functional as habitat or for movement of regionally significant fauna that are likely to be detected by motion-sensing cameras.

## Methods

To undertake this study, six sites were selected for deployment of motion-sensing trail cameras in the upper reaches of Sassafras Creek (Fig. 1). Overall, the sites were positioned to reflect a gradient of habitat quality, from highly urbanised through to weed-free remnant vegetation (Table 1). The six sites were classified into three classes relating to the origin of the present vegetation: 1) *original*, represented by areas that comprised remnant vegetation with sparce or absent weed cover (Fig. 2a); 2) *revegetated*, represented by areas that have been degraded but are now revegetated with native species (Fig. 2b); 3) *modified*, represented by an environment that had been cleared of native vegetation and is presently dominated by exotic species (Fig. 2c). Vegetation origin was expected to be the most influential driver of faunal activity in comparisons between sites (see below).

All footage was captured using the Bushnell TrophyCam HD (model #119876), inserted with a 32 GB SD card. Each camera was set to record a 60s video clip with a 0.6s re-trigger time. Camera sensitivity was programmed to 'high', LED flash intensity at 'low', and an image resolution of 1920 × 1080 pixels was specified. All videos were set to display the time, date stamp and temperature. The SD cards and

**Table 1.** Description of the selected study sites including the number of days the camera traps were active and the vegetation types, including ecological vegetation class (EVC) (DELWP 2020b).

| Site description | Date surveyed | Origin | Vegetation type |
|---|---|---|---|
| Site A: An urbanised setting with introduced grasses, pines and shrubby cover. Little native vegetation. | 28 February –10 May 2020 | Modified | Urban |
| Site B: Damp fertile soil adjacent to the Sassafras Creek. Well-shaded with abundant Soft Tree Ferns *Dicksonia antarctica* comprising the midstorey. | 28 February –10 May 2020 | Original | Wet Forest (EVC 30) |
| Site C: A Wet Forest site with a canopy of Mountain Ash *Eucalyptus regnans* and the ground cover dominated by Wandering tradescantia *Tradescantia fluminensis*. Revegetation of understorey. | 28 February –10 May 2020 | Revegetation | Wet Forest (EVC 30) |
| Site D: A revegetated site originally dominated by Sycamore Maples *Acer pseudoplatanus*. The site still contains introduced species that comprise the canopy and midstorey. The ground cover and understorey primarily comprised planted native vegetation. | 28 February –25 July 2020 | Revegetation | Wet Forest (EVC 30) |
| Site E: Moist damp soils adjacent to the creek. Southern Sassafras *Atherosperma moschatum* and fern-dominated ground layer. Few weeds present. | 28 February –25 July 2020 | Original | Cool Temperate Rainforest (EVC 31) |
| Site F: A low-light, tree-fern dominated area with damp soils adjacent to Sassafras Creek. Few weeds present. | 28 February –25 July 2020 | Original | Cool Temperate Rainforest (EVC 31) |


**Fig. 2.** Exemplar images of a) original native vegetation in cool temperate rainforest; b) revegetation site in wet forest; c) modified vegetation in the urbanised site adjacent to the reserve.

batteries were renewed fortnightly. Some small adjustments were made to the locations of the cameras, and the number of trap days was recorded for each location. The total number of survey days was 148, within the period 28 February to 25 July 2020. At each of the sites, the cameras were carefully strapped to a tree and positioned within 1 m of the ground to capture ground-dwelling animals. Cameras were not baited.

Counts of trigger events were compiled for each species over the duration of the survey. If the same species was detected at a site more than once on the same date, it was recorded as a single trigger event (detection event) for analysis. This was to limit multiple recordings of the same animal.

Specific contrasts were investigated relating to vegetation and faunal activity. Firstly, it was of interest to test for an association between the origin of habitat (i.e., original, revegetation or modified) and origin of species detected (i.e., native or introduced). It was expected that native species would be positively associated with the original and revegetated sites, while introduced species were expected to be associated with the modified site.

Secondly, activity of the introduced European Red Fox *Vulpes vulpes* was investigated for any association with the origin of vegetation at a site. Foxes are a key threat to ground-dwelling fauna in SCNCR and Fox control is a specific management action, ranked second to removal of weeds, in state Biodiversity Response Planning for this area (DELWP 2020a). Foxes were expected to be associated with disturbed and modified landscapes; hence, a test was undertaken for associations between vegetation origin and the number of days a Fox was detected, compared with the number of days where no Fox was detected.

A Chi-square test of independence was applied for each contrast of interest, and standardised residuals with Bonferroni correction were used to interpret significant associations between groups. Comparisons were graphically presented as a trap rate (i.e., number of days a species was detected/total days the camera was operating at a site) between the defined categories.

**Results**

A total of 292 detection events comprising 32 species was detected in the SCNCR between 28 February and 25 July 2020. This included 15 bird species, 16 mammal species and one species of crustacean (Table 2; see Fig. 3 for exemplar images). Of these, 24 species were native, while eight were introduced, including recognised pest species such as the Fox, Fallow Deer *Dama dama* and Sambar Deer *Rusa unicolor* (Figs 3c and 3d). Regionally significant species included the Mountain Brushtail Possum/ Bobuck *Trichosurus cunninghami* (Fig. 3a) and the Long-nosed Bandicoot *Perameles nasuta* (Fig. 4). The Superb Lyrebird *Menura novaehollandiae* was detected on eight occasions, while the Dusky Antechinus *Antechinus swainsonii* and Agile Antechinus *Antechinus agilis* were detected on four and 10 occasions, respectively.

The origin (native or introduced) of species captured on cameras was associated with the different habitat types ($\chi^2$ =36.87, df = 2, p<0.01). *Post-hoc* examination of residuals (with Bonferroni correction) revealed that there were significantly more detections of introduced species than native at the modified site (std. residual = 5.96, p<0.05). The sites comprising original vegetation had a trend

**Table 2.** The number of detection events of individual species at sites grouped by vegetation origin. Included is the total number of trap days for each vegetation origin and the total number of trigger events for each species across vegetation groups.

| Common name | Scientific name | Modified (72 trap days) | Original (283 trap days) | Revegetation (220 trap days) | Total |
|---|---|---|---|---|---|
| Agile Antechinus | *Antechinus agilis* | | 9 | 1 | 10 |
| Australian Magpie | *Gymnorhina tibicen* | 2 | | | 2 |
| Bare-nosed Wombat | *Vombatus ursinus* | 1 | 10 | 1 | 12 |
| Bassian Thrush | *Zoothera lunulata* | | | 3 | 3 |
| Black Rat | *Rattus rattus* | 13 | | 1 | 14 |
| Brown Goshawk | *Accipiter fasciatus* | | 1 | | 1 |
| Brown Thornbill | *Acanthiza pusilla* | | | 1 | 1 |
| Burrowing Crayfish Sp. | *Engaeus sp.* | | | 1 | 1 |
| Bush Rat | *Rattus fuscipes* | | 11 | 2 | 13 |
| Cat | *Felis catus* | 2 | 1 | 4 | 7 |
| Common Blackbird | *Turdus merula* | 1 | 16 | 16 | 33 |
| Common Brushtail Possum | *Trichosurus vulpecula* | 1 | | 19 | 20 |
| Common Myna | *Sturnus tristis* | 6 | | | 6 |
| Common Ringtail Possum | *Pseudocheirus peregrinus* | 2 | 1 | 8 | 11 |
| Crimson Rosella | *Platycercus elegans* | 4 | | 2 | 6 |
| Dog | *Canis familiaris* | | | 1 | 1 |
| Dusky Antechinus | *Antechinus swainsonii* | | 4 | | 4 |
| Eastern Yellow Robin | *Eopsaltria australis* | | 19 | 6 | 25 |
| Fallow Deer | *Dama dama* | | 5 | 1 | 6 |
| Laughing Kookaburra | *Dacelo novaeguineae* | 2 | | 1 | 3 |
| Long-nosed Bandicoot | *Perameles nasuta* | | 1 | | 1 |
| Magpie-lark | *Grallina cyanoleuca* | 1 | | | 1 |
| Mountain Brushtail Possum/Bobuck | *Trichosurus cunninghami* | | 3 | 5 | 8 |
| Pied Currawong | *Strepera graculina* | | 1 | | 1 |
| Red Fox | *Vulpes vulpes* | 21 | 16 | 6 | 43 |
| Red Wattlebird | *Anthochaera carunculata* | 3 | | | 3 |
| Rufous Fantail | *Rhipidura rufifrons* | | | 1 | 1 |
| Sambar Deer | *Rusa unicolor* | | 2 | | 2 |
| Short-beaked Echidna | *Tachyglossus aculeatus* | | 1 | | 1 |
| Superb Lyrebird | *Menura novaehollandiae* | | 1 | 7 | 8 |
| Swamp Wallaby | *Wallabia bicolor* | | 16 | 20 | 36 |
| White-browed Scrub-wren | *Sericornis frontalis* | | 6 | 2 | 8 |
| **Total** | | **59** | **124** | **109** | **292** |

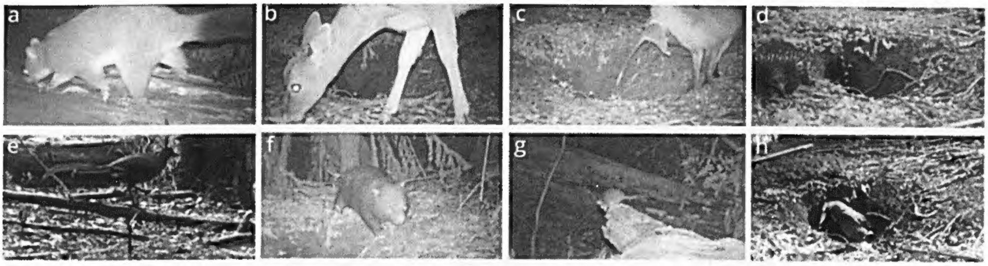

**Fig. 3.** A selection of species detected on camera traps in Sassafras Creek Nature Conservation Reserve; a) Mountain Brushtail Possum/Bobuck *Trichosurus cunninghami*; b) Fallow Deer *Dama dama*; c) European Red Fox *Vulpes vulpes* with a Common Ringtail Possum *Pseudocheirus peregrinus* in its mouth; d) Short-beaked Echidna *Tachyglossus aculeatus*; e) Superb Lyrebird *Menura novaehollandiae*; f) Bare-nosed Wombat *Vombatus ursinus*; g) Agile Antechinus *Antechinus agilis*; h) Pied Currawong *Strepera graculina*.

**Fig. 4.** A still image from video clip of a Long-nosed Bandicoot *Perameles nasuta* at Site E (Cool Temperate Rainforest).

for higher detection rate of native species (std. residual = 1.55, $p>0.05$), while native species showed an association with revegetation sites (std. residual = 3.36, $p<0.05$; Fig. 5).

The number of days when the European Red Fox was present at a site was associated with habitat type ($\chi^2 = 73.21$, df = 2, $p<0.01$). Foxes were present in modified habitat more than expected (std. residual = 8.5, $p<0.05$) and in revegetation less than expected (std. residual = -3.7, $p<0.05$), while showing no strong association with original vegetation (std. residual = -0.8, $p>0.05$; Fig. 6).

The vegetation between sites was of varying quality (in relation to weed cover) and thus small mammals were expected to correspond with this gradient between sites. As expected, the introduced Black Rat *Rattus rattus* was detected most often at the modified site (13/72 trap days). Interestingly, this species was found infrequently at the revegetation sites (1/220 trap days) and was not detected in sites with original vegetation. There were no native Bush Rats *Rattus fuscipes* or Agile Antechinus *Antechinus agilis* identified at the modified site, possibly reflecting sensitivity to habitat modification by these two native species. Both were detected at revegetation sites (2 and 1/220 trap days, respectively), albeit at a lower rate compared with sites comprising original vegetation (11 and 9/283 trap days, respectively).

There was a small number of detections of Mountain Brushtail Possum, or Bobuck, at the original (3/283 trap days) and revegetation sites (5/220 trap days), while the Common Brushtail Possum *Trichosurus vulpecula* was most prevalent at the revegetation site (19/220 trap days).

**Discussion**

There were several significant species recorded during this fauna survey. The Bobuck, is a regionally significant species in the Dandenong Ranges (Incoll *et al.* 2018). The species is reliant upon large tree hollows for denning during the day and access to Silver Wattles *Acacia dealbata*, their primary food source (Lindenmayer *et al.* 1996). While the species is likely to be limited by these resources, the Bobuck has been shown to use linear habitats where native vegetation remains (Martin and Handasyde 2007). In this study, the Bobuck was recorded by multiple trigger events within original cool temperate rainforest vegetation and at revegetation sites, suggesting the corridor is providing high-quality resources that support these possums. This species was last recorded in the SCNCR in 1992, 28 years before this survey (VBA 2020). Another regionally significant species is the Long-nosed Bandicoot, detected in weed-free

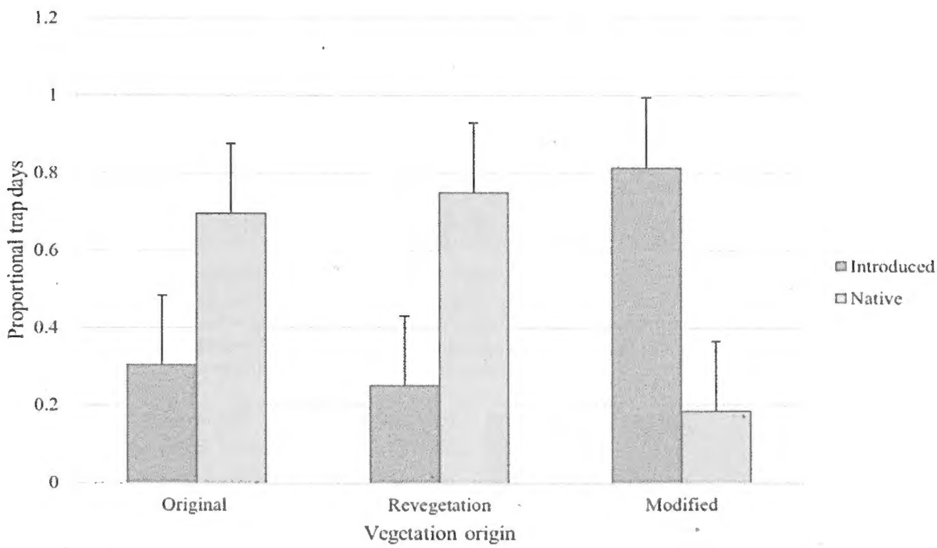


**Fig. 5.** Comparison of the species origin (introduced or native), for the three categories of vegetation origins: modified, original and revegetation. Standard error is included.

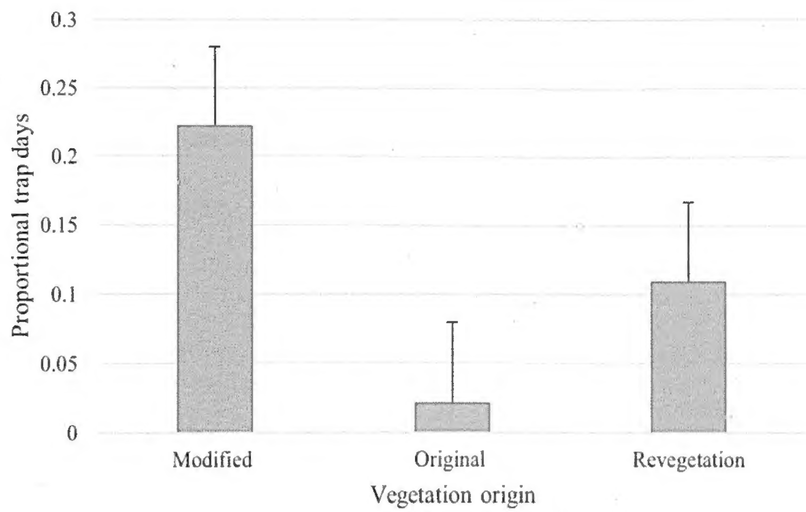


**Fig. 6.** Proportional trap days Fox presence at the six sites that are categorised by vegetation origin: modified, original and revegetation. Standard error is included.

rainforest habitat. Of all locations surveyed, the Cool Temperate Rainforest is likely to represent the most suitable habitat for bandicoots, primarily due to dense ground vegetation such as the Mother Shield Ferns *Polystichum proliferum* that provide shelter and ample food resources (e.g., fungi and insects in moist litter). Over the 148 days that the rainforest camera was active, there was only one detection of a bandicoot. This suggests that the

Long-nosed Bandicoot is rare in the corridor. The last record of Long-nosed Bandicoot in the reserve was lodged in the VBA by a FOSC member in 2016. Both Bobuck and Long-nosed Bandicoot are likely to be uncommon in the Dandenong Ranges and their population trajectory in the region is poorly understood.

The records of significant fauna within revegetation sites suggest there may be positive outcomes stemming from local conservation efforts. The Superb Lyrebird was also recorded at revegetation sites. This ground-foraging bird has been recognised as an 'ecosystem engineer' due to its foraging activity (Maisey *et al.* 2020), an important process for ecosystem function. Therefore, restoration work in the reserve considers the habitat requirements for lyrebirds (e.g., revegetation with rainforest vegetation to form dense middle-storey). Sightings of colour-marked individuals from Sherbrooke Forest confirm that lyrebirds utilise the reserve as a corridor to access the Olinda unit of the Dandenong Ranges National Park (Sherbrooke Lyrebird Survey Group, unpubl. data 2021). Moreover, two active nests were detected in the reserve while undertaking this survey, suggesting the corridor also provides suitable nesting sites for lyrebirds. Both were successful to fledging and one has subsequently been sighted on private property during 2021 (AM, pers. obs. 18 February 2021). Furthermore, the Superb Lyrebird was recorded in revegetated habitat in areas that had previously undergone treatment of ground-smothering weeds that are known to impede foraging. Overall, the presence of the lyrebird within these sites suggests that the weed control and revegetation in the corridor is helping to support permanent habitat and movement of regionally significant fauna throughout the landscape.

While the presence of the Bobuck, Long-nosed Bandicoot and Superb Lyrebird are encouraging indicators of a functional ecosystem, these significant species were detected at low rates. This may signify that there are many challenges facing these populations in a peri-urban setting. Fragmented habitat intersected by roads and housing adjacent to the corridor present risks to wildlife, while domestic pets on private properties are also likely to threaten these species if they come into contact. Several road mortalities of Superb Lyrebirds have been recorded in the last five years within the SCNCR (Sherbrooke Lyrebird Survey Group unpubl. data, 2021). Dog walking is permitted within the reserve, providing these animals are leashed; however, it is common to see walkers with dogs off-lead (JA, pers. obs. 2021), potentially affecting wildlife behaviour through their direct disturbance and scent trails (Lenth *et al.* 2008).

The removal of ground-smothering weeds and introduced trees that dominate the canopy (e.g., Sycamore Maple *Acer pseudoplatnus*) is essential to restoring ecological function in this peri-urban environment. Because much of the effective habitat of the reserve crosses into private properties, landowners play an important role in maintaining the health of this corridor. Collaboration between private landowners, government stakeholders and environmental community groups is essential, as without management of invasive species on private property, the reserve is at risk of ongoing weed incursion. Major environmental weeds such as English Ivy *Hedera helix*, Sycamore Maple and Wandering Tradescantia *Tradescantia fluminensis* smother native ground vegetation and create a barrier between animals and their litter-dwelling prey, likely posing a significant threat to ground-foraging fauna detected during this survey. Such weeds are best controlled with a 'tenure blind' approach across public and private land. This study has documented regionally significant species foraging in areas where introduced weeds have been removed, followed by subsequent replanting of native vegetation.

Over the course of the study, eight introduced species were detected. Unsurprisingly, modified and urbanised environments were found to have the greatest detection rates of introduced species. The European Red Fox poses serious threat to native species, highlighted by the image captured of a Fox with a Common Ringtail Possum in its mouth (Fig. 3c). Management of this pest animal is likely to have a strong influence over future conservation of fauna. A Fox control program coordinated by Parks Victoria throughout the Dandenong Ranges National Park has been credited with the successful regional recovery of the Lyrebird population (Sherbrooke Lyrebird Survey Group unpubl. data, 2020). While Fox control within

the SCNCR would likely provide great benefit to native species, such programs have not been possible with current Fox control methods. However, spill-over effects from the national park baiting program are likely to confer benefits to native species in the corridors.

Two species of deer were also detected within the reserve. Their presence has many detrimental impacts on habitat, including erosion of creek banks, caused by their hard hooves; sedimentation and increased turbidity in streams caused by wallows; and mortality of native vegetation due to over-browsing (Davis *et al.* 2016). For revegetation efforts to be successful, protection of plants from deer must be considered and implemented where possible. An effective state-wide deer control strategy will be a critical step in maintaining healthy habitats into the future and must be made a priority.

Long-term monitoring projects are vital for evidence-based conservation action. To measure the effectiveness of management strategies aiming to restore wildlife populations, surveys need to be conducted over prolonged periods. While this study lacks replication in survey sites, it has provided contemporary records of regionally significant species such as the Long-nosed Bandicoot and Bobuck in the SCNCR. Over the long-term, this monitoring data may provide a baseline to inform conservation decisions and influence the funding prospects for restoration management, especially when species of conservation interest are detected (Lindenmayer and Likens 2010).

This study provides new records of regionally significant species in the Dandenong Ranges, such as Long-nosed Bandicoot and Bobuck in both areas of remnant rainforest and areas cleared of weeds and revegetated with native species. The findings paint a positive picture of conservation action by local community groups and suggest the reserve is functional as both a wildlife corridor as well as permanent habitat for many species, with potential to support wildlife to a greater degree in future if further weed and pest animal management strategies continue to be implemented and strengthened throughout the Dandenong Ranges.

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# The impact of Yellow-tailed Black-Cockatoo *Calyptorhynchus funereus* (Shaw, 1794) feeding on a Monterey Pine *Pinus radiata* D.Don.

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## Abstract

The Yellow-tailed Black-Cockatoo *Calyptorhynchus funereus* consumes seeds and wood-boring insect larvae from woody-fruited native species such as *Hakea, Casuarina, Allocasuarina, Eucalyptus* and *Banksia* and from *Acacia* as well as seeds from the cones of introduced pine species. While its feeding on pine seeds is well known, there have been few studies describing the details of this feeding behaviour or its impact on the trees.

An opportunity to collect such data arose in 2020 when a single Monterey (Radiata) Pine *Pinus radiata* was visited on three occasions by small flocks of Yellow-tailed Black-Cockatoos. The behaviour of these birds during feeding sessions was observed over three days and the fallen debris of small and large needle-bearing shoots and cones was collected, sorted and categorised. Large and short needle-bearing shoots were counted and weighed. Eight birds visited the tree on the first day, two fed on the second day and four on the final day of feeding. The Cockatoos harvested 721 large and short needle-bearing shoots with a total mass of 19 552 g and 392 cones weighing nearly 17 kg. Only 134 cones (34.18%) with damage greater than 51% had all seeds removed. (*The Victorian Naturalist* 139(1), 2022, 13–20)

**Keywords:** harvesting of seeds from pine cones, feeding session, Black-Cockatoos, defoliation

## Introduction

The Yellow-tailed Black-Cockatoo *Calyptorhynchus funereus* (Shaw, 1794) is unusual among cockatoos in that it consumes seeds and large numbers of wood-boring insect larvae (McInnes and Carne 1978; Higgins 1999). It is Australia's longest Black-cockatoo, reaching 55–65 cm in length (Higgins 1999; Forshaw 2002; Harris 2007; Way and van Weenen 2008) and is known to feed on the seeds of both native and exotic trees. The seeds of, and wood-boring larvae in, *Acacia, Hakea, Casuarina, Allocasuarina, Eucalyptus* and *Banksia* are consumed, but the species also feeds on seeds in cones of exotic species such as Aleppo Pine *Pinus halepensis* Mill, Monterey (Radiata) Pine *Pinus radiata* D.Don. and Bhutan Cypress *Cupressus torulosa* D.Don. (Higgins 1999; Forshaw 2002; Way and van Weenen 2008).

There has been interest in the feeding and damage done to plantation forestry species such as Monterey Pine and Flooded Gum *Eucalyptus grandis* W.Hill by Australian birds, including the Yellow-tailed Black-Cockatoo (Graham 1928; Pawsey 1966; Gepp 1976; McInnes and Carne 1978; Way and van Weenen 2008). The Cockatoos peel off large strips of bark and then excavate wood to extract the larvae from the heartwood, not only damaging the timber, but causing trees to snap in storms, with up to 40 % of trees in some plantations being lost due to Cockatoo damage (McInnes and Carne 1978). Similar damage has been reported for native trees and shrubs, such as eucalypts, wattles and hakeas, by birds excavating the heartwood for larvae (Way and van Weenen 2008).

Yellow-tailed Black-Cockatoos are known to revisit feeding sites, not only day after day but also year after year (Noske 1980; Way and van Weenen 2008). Cockatoo flock sizes vary with species, seasonally and with the availability of food (Higgins 1999; Cameron 2005). Over the past 10–15 years, small flocks of up to 30 birds have been observed moving along the Maribyrnong River banks, west of Melbourne, often feeding from wattle and eucalypts, and ultimately arriving at Brimbank Park, a large metropolitan park in Melbourne's west. They would then spend a number of days (often 10–28 days) feeding within the park, but also venturing from the park to feed from pine species in the nearby village of Keilor and on individual Monterey Pines growing in suburban Kealba.

There is a single large Monterey Pine growing in a vacant suburban block in Kealba, adjacent to Brimbank Park. In the past, this tree has been visited regularly by Yellow-tailed Black-Cockatoos. When the birds were observed feeding in Brimbank Park and, later, in Keilor, plans were made to monitor their behaviour should they visit the Kealba tree.

The cones of Monterey Pine are serotinous and often require a trigger such as heat or fire for the release of seeds. The scales are capable of remaining closed for several years, so a succession of cones can result in cumulative seed crops being stored in the canopy for years (Centre for Agriculture and Bioscience International [CABI] 2020). The scales can also open and then close again depending on environmental conditions, releasing small numbers of viable seeds over a couple of decades. Old cones can remain attached to a tree for many years after they have opened and all seed within has been shed (Cope 1993). Monterey Pine is monoecious, with the small male cones occurring lower on the tree than the female cones, and only the female cones are retained (Walden *et al.* 1999).

The Monterey Pine in the vacant block at Kealba is a large, forty-year-old tree that is usually the domain of a family of Little Ravens *Corvus mellori* Matthews, 1912, which have both roosted and perched there at various times during the day, but have never nested in it. The Ravens are no match for the Yellow-tailed Black-Cockatoos, whose arrival is announced by a cacophony of shrieks mixed with the calls of the Ravens. The Ravens soon depart, leaving the Cockatoos to feed in peace; however, they usually return within 10 minutes of the Cockatoos' departure, so they must be keeping watch over the tree.

Yellow-tailed Black-Cockatoos, while not as loud or raucous as the Sulphur-crested Cockatoo *Cacatua galerita* (Latham, 1790), make their presence known with a series of calls and whistles (Higgins 1999). They are diurnal and noisy, and, with the loud responses of the Ravens, their arrival at the tree would be heard during the Covid-19 lockdown period in Victoria, when people were restricted to their homes. It would provide an opportunity to collect data on the removal of cones and needle-bearing shoots.

**Methods**

Yellow-tailed Black-Cockatoos arrived at the tree in early October 2020. Their feeding sessions were timed from the beginning until the last bird departed the tree. Birds of a flock arrived within seconds of each other and stopped feeding within seconds of each other. The numbers of birds present at each feeding session were counted. Despite the birds being difficult to see in the canopy, small flock sizes of two to eight birds and lengthy feeding sessions made accurate counts possible along with observations of different aspects of their feeding behaviour.

All small and large needle-bearing shoots and cones dropped by the birds during feeding sessions were collected separately after the final feeding session. Prior to the arrival of the flocks, the ground around the tree was tidied so that freshly fallen material could be readily identified. The fine debris on the ground following feeding sessions was not collected as it was too small and scattered more widely. The site was inspected daily for ten days after the departure of the Yellow-tailed Black-Cockatoos in order to collect any cones or needle-bearing shoots that had been snagged in the tree and fallen to the ground later.

The number and weight of the cones that had been removed were determined. Cones were categorised according to the degree of discernible damage done using a seven-point

Table 1. Feeding hours of Yellow-tailed Black-Cockatoos feeding on a Monterey Pine.

| Feeding session | Number of birds | Duration (hours) | Feeding hours |
|---|---|---|---|
| 1 | 8 | 1.5 | 12.0 |
| 2 | 2 | 1.25 | 2.5 |
| 3 | 4 | 1.0 | 4.0 |
| Total feeding hours | | | 18.5 |

Table 2. Number and mass of needle-bearing shoots removed from Monterey Pine by Yellow-tailed Black-Cockatoos.

| | Number | Weight (g) | Average weight (g) | Number of cones on shoots |
|---|---|---|---|---|
| Small shoots (<100g) | 668 | 10 168 | 15.2 | 0 |
| Large shoots (>100g) | 16 | 1755 | 109.7 | 0 |
| Large shoots with undamaged cones | 37 | 7629 | 206.2 | 70 |
| TOTAL | 721 | 19 552 | | 70 |

scale: 0 (no damage); + (evidence of minor damage), 1(<10% damage); 2(11–30% damage); 3(31–50% damage), 4(51–70% damage) and 5(>71% damage).

Needle-bearing shoots were separated into three groups: small, large, and those with undamaged cones. For each group, the shoots were counted and weighed to determine the mass of material removed. After the final feeding session, the tree was scanned with Tasco 10 × 25 binoculars to determine whether any cones of the same comparative size and age of those removed had been left on the tree. Scanning was done from the ground, but since most of the canopy of the tree could be seen, a reasonably accurate count could be made.

To allow quantification of feeding sessions that involved different flock numbers and different durations, a concept of bird-feeding-hours was utilised, where the number of feeding birds was multiplied by the feeding time in hours. This enabled the rates of removal of pine cones and large and small needle-bearing shoots and their respective masses to be calculated. The average rates of removal per bird were also estimated.

## Results

Three feeding sessions were observed (Table 1). Eight birds fed for 1.5 hours in the first session, two birds fed for 1.25 hours in the second session and four birds fed for 1.0 hour in the final session. Using the feeding hour concept, the Yellow-tailed Black-Cockatoos fed on the Monterey Pine for a total of 18.5 hours (Table 1).

The Yellow-tailed Black-Cockatoos first arrived at the tree on 1 October 2020; they returned on the next two days. On the first day, when eight birds were present, one bird kept up a low almost croaking/growl call for the whole time that the birds were there and was probably a juvenile bird. There was no such calling when the smaller numbers of birds were feeding on days 2 and 3; these latter sessions occurred in near silence except for the occasional low call and the cracking of woody shoots and cones and the thuds as cones landed. In every case that could clearly be observed, the Cockatoos used their left foot to manipulate the cones while feeding. The beak was used to dismantle the cones and to sever shoots and cones from the tree.

Over these three days, the Cockatoos removed 668 small shoots from the tree (Table 2), ranging in weight from 1 to 100 g but averaging 15 g. Fifty-three large needle-bearing shoots were removed (Table 2), each weighing more than 100 g; the largest weighed 898 g. Some of these larger shoots were over 600 mm in length (Fig. 1). The total weight of large shoots (9384 g) was less than that of small shoots (10 168 g) (Table 2). Thirty-seven of the larger shoots also had untouched, generally small cones attached (Table 2). No damage was done to the tree or detached shoots by birds in search of larvae.

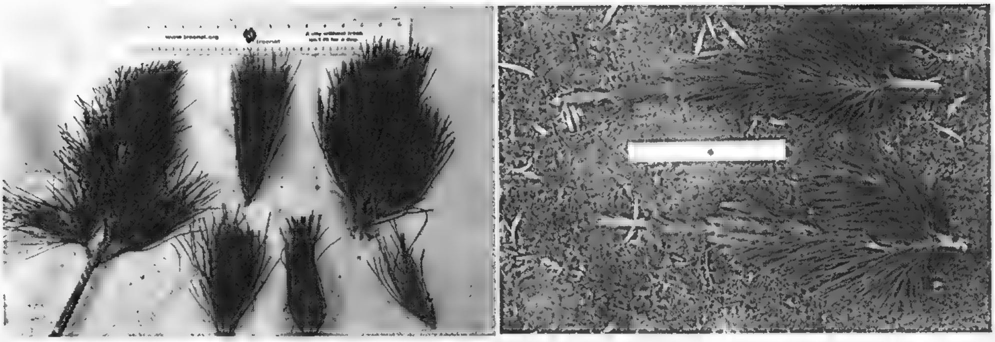

**Fig. 1.** Examples of small shoots (left) and large shoots greater than 60 cm long (right) removed from Monterey Pine by Yellow-tailed Black-Cockatoos.

**Table 3.** Number, mass, size and level of damage exhibited by cones removed from Monterey Pine by Yellow-tailed Black-Cockatoos.

| Level of damage | Number of open cones | Closed cones | Status of seed | Mass of cones (g) | Ave. mass of cones (g) |
|---|---|---|---|---|---|
| 0 None | | 34 | None removed | 1816 | 53.41 |
| 0 None | 6 | | None present | 392 | 65.33 |
| + Minor | 151 | 0 | None removed | 8023 | 53.13 |
| 1 (<10%) | 29 | 0 | Some removed | 1556 | 53.67 |
| 2 (11-30%) | 17 | 0 | Many removed | 788 | 46.35 |
| 3 (31-50%) | 21 | 0 | Most removed | 880 | 41.90 |
| 4 (51-70%) | 26 | 0 | All removed | 922 | 35.46 |
| 5 (>71%) | 108 | 0 | All removed | 2426 | 22.46 |
| TOTAL | 358 | 34 | | 16803 | 42.86 |

The most obvious result of the Cockatoos feeding on the tree was the large number of cones (392) found on the ground after the feeding sessions (Table 3). These were cones only, without any foliage attached. All were a light brown or tan colour except for six, which were grey and typical of older cones. It was interesting to note that many of the cones opened by the birds had approximately the same width and length.

Of the cones removed, 40 (10.0%) showed no damage from feeding (Table 3; Fig. 2) and, of these, 34 had not opened at all (Table 3). The other six cones were older fully open cones containing no seeds (Table 3). Another 151 (38.5%) had very little damage and no evidence of seed removal (Table 3). At first glance these appeared to have no damage, but closer inspection showed very slight damage caused by the beaks of the Cockatoos. Usually, but not always, the damage was to the smallest scales at the tip of the cone (114 cones), to the tip and middle scales (28 cones) and rarely at the base of cones (nine cones). On these cones, none of the scales had been completely removed, as was the case for the more significantly damaged cones (Fig. 2). There were 201 dropped cones that showed more significant damage (>10%) from Cockatoo feeding (Table 3; Fig. 3). Once damage to the cones exceeded 50%, no seed remained within them (Table 3).

The average weight of cones declined as the damage to cones increased (Table 3). This was expected as greater damage to the cone resulted in a greater amount of missing cone structure.

After the feeding sessions, there was a lot of fine debris on the ground consisting of scales and bits of scales that had been removed from cones, and some winged seeds (Fig. 4). Four days after the last feeding session, pieces of


**Fig. 2.** Examples of Monterey Pine cones with closed scales (left) and cones showing a range of damage caused by Yellow-tailed-Cockatoos (right).


**Fig. 3.** Cones of Monterey Pine showing greater levels of damage after seed harvesting by Yellow-tailed Black-Cockatoos. The most severe damage is shown on the right and is very similar to that found in Aleppo Pine by Way and van Weenen (2008).

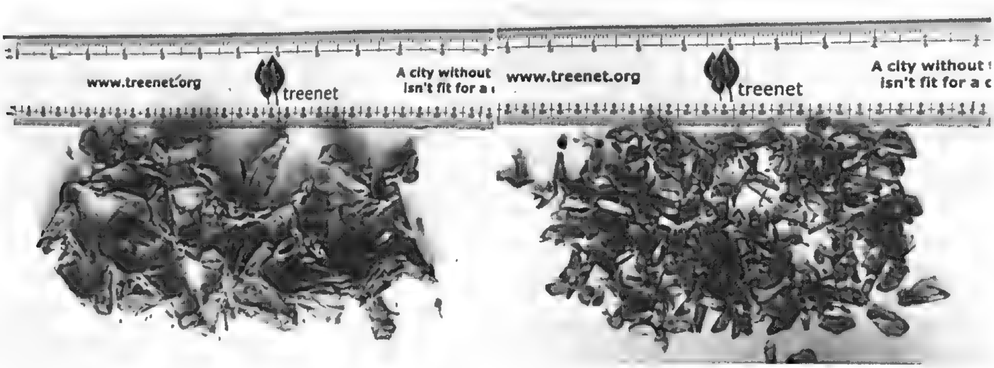


**Fig. 4.** Pieces of cones and cone scales (left) and the viable winged seeds (right) left after harvesting of seeds from a Monterey Pine by Yellow-tailed Black-Cockatoos.

**Table 4.** Calculated feeding rates on cones and needle-bearing shoots of Monterey Pine by Yellow-tailed Black-Cockatoos.

| | Needle-bearing shoots | | Cones | |
|---|---|---|---|---|
| | Number | Mass (g) | Number | Mass (g) |
| **Per feeding hour** | 38.97 | 1056.86 | 21.19 | 908.27 |
| **Feeding session 1** | 467.64 | 12682.32 | 254.28 | 10899.24 |
| **Feeding session 2** | 97.43 | 2642.15 | 52.98 | 2270.68 |
| **Feeding session 3** | 155.88 | 4227.44 | 84.76 | 3633.08 |
| **TOTAL** | 721.00 | 19552.00 | 392.00 | 16803.00 |

cone scales could still be found, but no pine seeds remained.

Scanning the tree with binoculars after the feeding sessions revealed that hundreds of the old, grey, open cones remained. There were 12 large (estimated as > 8 × 8 cm), green, closed-cones still attached to needle-bearing shoots and at least 100 small cones (estimated as < 3 × 3 cm) attached to shoot apices. It is likely that there were more of these smaller cones hidden by foliage that could not be seen from the ground. No light brown cones of the size or age collected in the dropped material could be seen.

The Yellow-tailed Black-Cockatoos spent a total of 18.5 feeding hours at the Monterey Pine. They removed 721 foliage-bearing shoots with a mass of 19552 g (Table 2) and 392 cones with a mass of 16803 g (Table 3). Dividing these totals by the feeding hours (18.5), the rate of removal of cones and long and short needle-bearing shoots per hour and per feeding sessions were calculated (Table 4).

## Discussion

The impact of a flock of Yellow-tailed Black-Cockatoos feeding on a tree is significant. Even a small flock of birds can remove large numbers and masses of both cones and needle-bearing shoots. The birds remove cones and feed on the winged seeds within, using their left foot to manipulate the twigs and cones and their beaks and tongues to sever the plant parts and extract the seeds. All birds observed clearly used the left foot for manipulation, which is consistent with other reports that cockatoos are predominantly, if not exclusively, left footed (Brown 2011; Brown and Magat 2011).

As previously reported by Dawson (1994), the birds systematically lifted and often removed each scale. Dawson (1994) estimated that birds spent about 20 minutes dissecting a cone and had a preference for green cones but, in this study, the Cockatoos harvested an average of 21.19 cones in an hour, so were spending an average of less than three minutes on each cone. Older birds are also known to remove cones more rapidly than younger birds (Cameron 2005). This difference in feeding time may be explained partly by the fact that nearly half the cones were removed with little, if any, damage. Only 134 cones (34.18 %) with damage greater than 51 % had all seeds removed, so removal of scales and seeds would have taken longer. Cones that suffered greater than 51 % damage were very similar to those illustrated for Aleppo Pine by Way and van Weenen (2008). Green cones were left largely intact.

In contrast to the cones with little damage, the pattern of the most severe damage done usually saw the smaller scales toward the apex left intact (Fig. 3). The scales toward the centre of the cones were often damaged and, in many cases, removed from the axis of the cone altogether, as were the scales towards the base of the cone. This pattern was consistently displayed in cones with more than 51 % damage, but was particularly evident when damage exceeded 71 %. It seems likely that no seeds occurred in these apical scales, so the birds did not waste time or energy in damaging them further. This is consistent with the efficient foraging strategies of other cockatoos (Clout 1989).

The Cockatoos removed over 36 kg of material from the tree. Removal of cones to feed on the winged seeds within is well-known, but 40 (10.0%) of the cones were undamaged and mostly closed, and another 151 (38.52%) had very little damage and no evidence of seed retrieval. Given that nearly 50% of the cones removed from the tree yielded no seed, this removal seems to be inefficient, as does the

removal of large shoots bearing cones that were all closed and undamaged by the birds.

None of the large, old, open cones on the tree were touched by the Cockatoos. This was to be expected as there would be no seeds in them and, so, there would be no incentive for exploration by the birds. There were so few cones of the type harvested by the Yellow-tailed Black-Cockatoos remaining that it would not be worth their while returning to feed from that tree for some years. The tree has been visited on three occasions over the past decade. A feeding-visit every three years or so seems likely to yield an appropriate number of cones of suitable size and age to make the visit productive for the birds.

The cones of the tree are known to contain viable seed as it has been collected and propagated in the past. However, there have been few occurrences of self-seeding in the vicinity of the tree and no known occurrences in nearby Brimbank Park. Yellow-tailed Black-Cockatoos have been reported as spreading Monterey Pine seeds and contributing to the distribution of the species as a weed (Gill and Williams 1996; Williams and Wardle 2005). In this study, the birds were not seen carrying any shoots, cones or other material from the site. All material that was dropped by the birds fell in the immediate vicinity of the tree and usually immediately below the canopy.

Furthermore, feeding by Yellow-tailed Black-Cockatoos significantly reduced the number of cones and seeds held on the plant; cones with damage greater than 51 % contained no seed at all. While the harvesting does not eliminate the risk that the tree might self-seed and present as a weed, it may significantly lessen its weed potential by reducing the seed bank, especially when the tree is regularly and repeatedly grazed. Larger flocks feeding on plantation populations of Monterey Pine on a regular basis could significantly reduce the seed bank held within the canopy of the trees, reducing their weed potential. The influence of Yellow-tailed Black-cockatoos on the seed stored in trees they harvest warrants further research.

The fine debris consisting of cone scales remained on the ground after the feeding sessions for weeks and became part of the site mulch. However, within four days of the last feeding session there were no pine seeds remaining. It would seem that these were eaten by other birds and, while it is uncertain which birds consumed the seeds, up to four Spotted Doves *Spilopelia chinensis,* (Scopoli, 1786) were observed feeding under the Monterey Pine. This ground-feeding could further reduce the seed bank and diminish the tree's weed potential. The feeding-debris deposited under the tree contributed substantially to the organic matter, adding to the quantity and the particle size diversity of the litter, which previously consisted almost entirely of pine needles. Such a change could impact the biodiversity of the organisms present in the litter.

The removal of large and small needle-bearing shoots without cones raises questions. Is this material removed with a purpose? What benefit do birds derive from its removal? The removal could be aimed at improving access to and manipulation of the cones and so, may be considered incidental damage. It may also assist birds to clean their beak of resin encountered during chewing of cones. The removal of so many needle-bearing shoots has a visible impact on the canopy of a tree, but is still a relatively small proportion of a large canopy. However, it opens up the canopy and the removed shoots tend to bear the younger greener foliage; as a result, this tree did not look as healthy as it did before the feeding sessions. While the overall effect is likely to be a slight reduction in photosynthetic activity, the longer-term implications remain unknown and would be worthy of further study.

While this study involved only a single Monterey Pine and small flocks of Yellow-tailed Black-Cockatoos, it revealed some interesting aspects of the birds' behaviour. It also provided some insight into the rate of feeding and the amounts of material that Yellow-tailed Black-Cockatoos can remove during a feeding session. Further research on larger numbers of trees and bigger flocks would provide valuable information concerning not only damage done to trees, but also the effects on seed banks held in tree canopies and the reduction in potential weediness of harvested species.

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## Fifty-eight Years Ago

### Black Cockatoos and Grass-trees

By K. G. Simpson

A paper by P. A. Gilbert (1935) records the Yellow-tailed Black Cockatoo *(Calyplorhyncus funereus* Shaw) extracting beetle larvae *(Cerambycidae, Coleoptera)* from dead flower spikes of the Grass-tree or Blackboy *(Xanthorrhoea* spp.) on the central New South Wales coastal strip ("Movements of birds, Pt. II —The seasonal movements and migrations of birds in eastern N.S.W.", *Emu* 34: 205). In June 1963, after reading the above record, I examined a large patch of *X. australis* R.Br., situated on the northern slope of a hill at Tidbinbilla, 25 miles west of Canberra. Evidence was found that extensive damage to flower spikes had occurred within the last two or three years. The damage was somewhat similar in appearance to that caused by *C. funereus* in extracting large moth larvae from several species of *Acacia* in the same district, a description of which is to be published shortly (Simpson, K. G., in press—*Emu)*.

From *The Victorian Naturalist* **81**, p. 217, December 10, 1964

# A case of unsupervised wildlife tourism involving kangaroos on a public hospital estate

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**Abstract**
There is a strong interest in wildlife tourism; however, some human-animal interactions may be unsupervised and lack management controls. The ethics of tourists using the estate of a psychiatric hospital to interact with (including feeding) wild Eastern Grey Kangaroos *Macropus giganteus* were debated. There was considerable argument. Some considered the hospital estate a convenient location to see kangaroos habituated to close encounters. Others objected, citing potential implications of tourist numbers on psychiatric patients and potential harm to kangaroos from feeding them artificial foods, and stress caused by some tourist behaviours. The issue gained widespread political and media attention in May 2018 following reports of tourists being injured. This eventuated in the land manager closing the site to the general public. Tourist interaction with kangaroos is not a new issue; however, a psychiatric hospital is an unlikely tourist attraction, making this case study unique.
(*The Victorian Naturalist* **139**(1), 2022, 21–30)

**Keywords:** human-animal interactions, food provisioning, wildlife management, wildlife tourism

## Introduction

Globally, there is insatiable interest in the potential of encountering wildlife in situ. This is embedded in wildlife tourism (Mutanga *et al.* 2017; Newsome *et al.* 2019). Human-animal interactions in wildlife tourism range from strictly observational activities (Cerri *et al.* 2019) to experiences involving physical contact with animals (e.g. Blewitt 2008; Newsome and Rodger 2013). Wildlife tourism contributes to conservation objectives by providing tourists with interpretive experiences that promote public familiarity and learning about the animals (Ballantyne *et al.* 2011) or establishing economic alternatives to the commercial harvesting of some species (Garrod and Wilson 2003; Cisneros-Montemayor *et al.* 2013). 'Ecotourism' is a concept formed in the late 20th Century. It prioritises the operation of tourism in a manner that is sustainable and does not damage natural values (Blumstein *et al.* 2017; Worrell *et al.* 2017).

Despite the benefits of wildlife tourism to conservation objectives, there are many tourist activities that attract concerns about the risks and impacts on animal welfare and conservation, animal behaviours and ecosystem health (Brookhouse *et al.* 2013; Trave *et al.* 2017). In particular, some human-wildlife encounters are unsupervised or unstructured (see Newsome and Rodger 2008), characterised by people knowing of locations frequented by certain animals and travelling there to interact with them (Newsome *et al.* 2004; Pocock 2006). In these scenarios, it is difficult for wildlife managers to regulate activities or implement controls to address risks and impacts. Some examples of unsupervised wildlife tourism include visits to bays to feed fish (Semeniuk *et al.* 2009), leaving out carcasses to attract carnivores to particular sites (Markwell 2015) and feeding birds and monkeys to encourage close interactions (Robb *et al.* 2008; Sengupta and Radhakrishna 2020).

Kangaroos (family Macropodidae) are some of the world's most recognisable tourism species (Higginbottom *et al.* 2004; Andrew 2015). Kangaroos are entrenched in the cultural identity of Australia, as demonstrated by their appearance on the Commonwealth Coat of Arms; marketing emphasis by the tourism sector; numerous kangaroo-related souvenir products; and their presence in almost every zoological facility in Australia. Conveniently for tourists, some species are abundant in many rural and urban areas of Australia (Fig. 1). Populations of Eastern Grey Kangaroos *Macropus giganteus* in some parts of capital cities, such as Canberra (Fletcher 2007) and Sydney (Colgan *et al.* 2019), are a case in point. However, kangaroos are also the focus of contentious management issues (Descovich *et al.* 2016). In heavily developed

Fig. 1. An adult male Eastern Grey Kangaroo being patted by a tourist in Morisset, NSW.

areas where kangaroos are abundant, motor vehicle collisions involving kangaroos may be frequent (Ballard 2008; Inwood *et al.* 2008) and there may be some aggression from kangaroos towards humans and domestic pets (Henderson *et al.* 2018). Abundant grazing on maintained lawns and the permanent water supply of these modified habitats allows kangaroo populations to flourish (Lunney 2010; Morgan and Pegler 2010), prompting some managers to seek measures to reduce their numbers (Herbert 2004; Tribe *et al.* 2014). As a result of these and other potential conflicts with humans, public perceptions of kangaroos are strongly polarised (Descovich *et al.* 2016).

Feeding wildlife, often termed food provisioning, is a contentious subject (Newsome and Rodger 2008). The practice has been promoted by some organisations and deterred by others (Jones 2011; Cox and Gaston 2016). Some of the negative consequences raised include: conditioning animals to the presence of humans and the associated increased risks of the animals suffering anthropogenic injuries (Christiansen *et al.* 2016); animal nutrition and health being compromised (Civitello *et al.* 2018); and alterations to natural behaviour patterns and population levels where provisioning occurs over a long period of time (Orams 2002). In this paper, a population of Eastern Grey Kangaroos on a public hospital estate north of Sydney is highlighted as a recently debated case of unsupervised wildlife tourism.


Fig. 2. The location of Morisset Hospital relative to the central township of Morisset, adjacent suburbs and the Morisset section of Lake Macquarie State Conservation Area. The Pacific Motorway is highlighted in the southwest corner of the map.

## Site description and history

The township of Morisset (33.11°S, 151.50°E) is situated on the Central Coast of New South Wales (NSW) between the major urban centres of Sydney and Newcastle. A major part of this region's geography is Lake Macquarie, the largest coastal saltwater lake in Australia, which spans approximately 120 km$^2$. The foreshore of Lake Macquarie stretches approximately 170 km, with Morisset situated in the south-western corner. The Morisset section of the foreshore consists primarily of the Morisset Hospital estate and one of six sections of the Lake Macquarie State Conservation Area (Fig. 2).

Morisset Hospital is a psychiatric facility managed by the Hunter New England Local Health District. The hospital is set on approximately 1244 ha of maintained lawn and remnant bushland. The estate is enclosed by larger tracts of bushland, including the Lake Macquarie State Conservation Area. Some of the vegetation communities represented in this area include Coastal Sandplain Scribbly Gum Forest, Estuarine Swamp Oak Forest, Coastal Alluvial Mahogany Swamp Forest, Coastal Alluvial Flat Swamp Forest, Narrabeen Coastal Clay Heath and Narrabeen Doyalson Coastal Woodland (Table 1). The estate is accessible from the Pacific Motorway, being less than 7 km away by road. A thin strip of land separating the hospital estate from Lake Macquarie is part of the state conservation area, within which is the Morisset Picnic Area (now closed), managed by the NSW National Parks and Wildlife Service (NSW NPWS).

Morisset Hospital holds high cultural significance in Morisset's history. The hospital (then the Morisset Asylum for the Insane) was officially opened in 1909, though the first patients were housed on the site in tents as early as 1906 (Morisset Hospital Historical Society 2000). The original 526 ha of the site were reserved for

**Table 1.** Vegetation communities present in the vicinity of the Morisset Hospital estate.

| Vegetation community | Characteristic vegetation |
|---|---|
| Coastal Alluvial Flat Swamp Forest | Smooth-barked Apple *Angophora costata*, Swamp Mahogany *Eucalyptus robusta*, Forest Red Gum *E. tereticornis*, Rough-barked Apple *Angophora floribunda*, Black She-oak *Allocasuarina littoralis*, Sydney Golden Wattle *Acacia longifolia*, Myrtle Wattle *A. myrtifolia*, Large-leaf Hop-bush *Dodonaea triquetra*, Cheese Tree *Glochidion ferdinandi*, Tantoon *Leptospermum polygalifolium*, Elderberry Panax *Polyscias sambucifolia*, Coffee Bush *Breynia oblongifolia*, Hairy Bush-pea *Pultenaea villosa* and Sunshine Wattle *Acacia terminalis* |
| Coastal Alluvial Mahogany Swamp Forest | Swamp Mahogany, Forest Red Gum, Smooth-barked Apple, Cheese Tree, Prickly Tea-tree *Leptospermum juniperinum* and Hairy Bush-pea |
| Coastal Sandplain Scribbly Gum Forest | Northern Scribbly Gum *Eucalyptus signata*, Red Bloodwood *Corymbia gummifera*, Smooth-barked Apple, Paperbark Tea Tree *Leptospermum trinervium*, Sunshine Wattle and Black She-oak |
| Estuarine Swamp Oak Forest | Swamp Oak *Casuarina glauca*, Forest Red Gum, Sea Rush *Juncus kraussii*, Bare Twig Rush *Baumea juncea* and Saw Sedge *Ghania clarkeii* |
| Narrabeen Coastal Clay Heath | Needlebush *Hakea teretifolia*, Fern Leaf Banksia *Banksia oblongifolia*, Tantoon, Wallum Heath *Epacris pulchella*, Red Spider Flower *Grevillea speciosa*, Slender Rice Flower *Pimelea linifolia*, Paperbark Tea Tree and Black She-oak |
| Narrabeen Doyalson Coastal Woodland | Scribbly Gum *Eucalyptus haemastoma*, Red Bloodwood, Brown Stringybark *E. capitellata*, Paperbark Tea Tree, Sweet Wattle *Acacia suaveolens*, Fern Leaf Banksia and hakeas *Hakea* spp. |

the hospital's construction in August 1900. In 1906, clearing commenced and the first building, the hospital's Recreation Hall, was completed in 1908. In 1920, more land was acquired for the hospital estate, expanding it to 1618 ha. The lawns of the estate provide a steady food supply for Eastern Grey Kangaroos from the adjacent bushland (Fig. 3) and the hospital estate was declared a wildlife refuge in 1972.

In the 1990s, 174 ha of the hospital estate, away from the main complex, was transferred to NSW NPWS. This land formed the Morisset section of the Lake Macquarie State Conservation Area (NSW NPWS 2005), which covers approximately 650 ha over six separated sections. The Morisset section was gazetted as part of the Conservation Area in January 1999.

**Fig. 3.** The lawns in front of the Recreational Hall of the Morisset Hospital are frequented by Eastern Grey Kangaroos, evidenced by this adult male and the high density of kangaroo dung.

**From local attraction to international drawcard**

The sight of kangaroos in the wild has great appeal for many people. This is recognised by a number of agencies that have provided information to facilitate the viewing of kangaroos in the wild (Office of Environment and Heritage (OEH) 2018; Tourism Australia 2018). These efforts have generally been underpinned by a focus on improving visitation to certain public reserves and secondary benefits for local economies. However, there has been an unprecedented rise in websites based on user-generated content, which allow members of the public to broadcast information. These online platforms include, but are not limited to, social media websites (such as Facebook and Instagram), video-sharing websites (such as YouTube) and travel websites (such as Tripadvisor). Whether deliberately or inadvertently, people sharing their experiences at the Morisset Hospital estate have publicised the site as a place to easily see kangaroos. The consequence has been that domestic and international visitors have been attracted to the site.

The provisioning of food to kangaroos has a long history in Morisset. The Morisset Hospital Historical Society (2000) published a book about the hospital's history, and the front cover featured a photograph of a hospital staff member hand-feeding an adult kangaroo. At some stage, this activity became a popular pastime amongst local people. Today, a large proportion of the images of the estate published on the internet are photographs taken by domestic and international tourists. Some of the photographs show crowds of people scattered across the lawns of the hospital estate interspersed with kangaroos.

Situated in the Greater Sydney region, Morisset is surrounded by structured tourist attractions. A simple search of zoological parks within a road distance of 200 km from Morisset found 15 such establishments (Table 2). The opportunity to interact with kangaroos is offered at 13 of these zoological parks, either through kangaroos displayed in walk-through exhibits or as free-roaming animals. Nevertheless, one explanation for the appeal of the hospital estate is the sentiment associated with interacting with kangaroos without boundaries. One quote, from a 23-year-old student from Spain, published in a media article, encapsulated this sentiment: 'This is so much more authentic than seeing them in the zoo' (Crawford 2013). Another explanation may be the lack of entrance fees. Although three of the zoological parks listed in Table 2 are smaller establishments with no entrance fees, none of them offer interactive experiences with kangaroos. The other zoological parks require payment upwards from $27.50.

Unlike an experience at a zoological park, tourist interactions with kangaroos in Morisset were on an unsupervised basis. This has reportedly led to intrusive actions by some tourists. A

**Table 2.** Comparisons of zoological parks within 200 km road distance of the Morisset Hospital estate. Admission is shown as entrance fees for adults advertised in January 2021.

| | Road distance (km) | Admission | Experience |
|---|---|---|---|
| Blackbutt Reserve, Kotara | 40 | Free, parking fees apply | View only |
| Australian Reptile Park, Somersby | 40 | $43.00 | Free-roaming |
| Hunter Valley Zoo, Nulkaba | 55 | $32.00 | Walk-through exhibit |
| Waterfall Springs Retreat and Wildlife Sanctuary, Kulnura* | 58 | $300.00-$450.00 | Free-roaming |
| Australian Walkabout Wildlife Park, Calga | 75 | $30.00 | Free-roaming |
| Oakvale Wildlife Park, Salt Ash | 78 | $29.50 | Free-roaming |
| Koala Park Sanctuary, West Pennant Hills | 102 | $28.00 | Walk-through exhibit |
| Central Gardens, Merrylands | 117 | Free | View only |
| Auburn Botanic Gardens Fauna Reserve | 118 | Free on weekdays, $4.00 on weekends, public holidays and school holidays | View only |
| Taronga Zoo, Mosman | 118 | $44.10 | Walk-through exhibit |
| Wild Life Sydney Zoo, Darling Harbour | 119 | $36.80 | Walk-through exhibit |
| Featherdale Wildlife Park, Doonside | 122 | $35.00 | Walk-through exhibit |
| Sydney Zoo, Bungarribee | 131 | $47.50 | Walk-through exhibit |
| Calmsley Hill City Farm, Abbotsbury | 142 | $27.50 | Walk-through exhibit |
| Symbio Wildlife Park, Helensburgh | 161 | $39.00 | Walk-through exhibit |

*Accommodation only

wildlife carer who regularly monitored the site was cited by a local journalist to have witnessed tourists taking joeys from pouches and climbing on the back of kangaroos (Moloney 2018). The same media outlet cited a wildlife carer stating she had warned tourists who were trying to cuddle an adult male (Harris 2014). One journalist reported observing a child attempting to box with a juvenile kangaroo until the animal stood erect in response (Gordon 2014). Examples of such behaviours have been highlighted in media articles dating back decades and have promoted fierce debates regarding the suitability of the site as an unsupervised tourism attraction and how to manage the situation.

### A debate over values

A review of comments posted on Tripadvisor shows a range of polarised views concerning tourist activities on the hospital estate (Table 3), which are ultimately underpinned by differing values. There were those who enjoyed the convenience of a location where kangaroos were reliably present and habituated to human interaction, though this cohort was still divided over whether kangaroos should be fed or watched without feeding. At the other end of the spectrum, a range of opinions were argued in opposition to tourists entering the hospital estate. A key theme relating to the primary purpose of the hospital showed that there is an ethical issue with tourists entering a property designated for the care of psychiatric patients. This viewpoint typically focused on the potential impacts of tourists on the welfare of patients, including intrusions on their space, and potential disruptions to hospital services. There were also concerns expressed about the general safety of tourists around patients.

Another key theme in the debate focused on the effect of tourist activities on the kangaroos' welfare, behaviour and fitness (Green 2017). Immediate impacts included stress caused by joeys being separated from their mothers and kangaroos being forced out of shade on hot days (Table 3). There were also concerns over long-term impacts on their health from being fed inappropriate food, including potato chips, biscuits (Millington and Farquhar 2018) and soap (Moloney 2018).

Another key theme was the danger kangaroos

**Table 3.** Varying views expressed on Tripadvisor postings on the use of the Morisset Hospital estate as an unofficial tourism attraction.

| Supporting | Opposing |
| --- | --- |
| I live in this area. This is a great place to see wild kangaroos and free. There's always kangaroos there but the best time to go is afternoon. They are friendly, let you pat them. We took visitors from overseas. They loved it. | The Morisset Psychiatric Hospital is private property with very ill psychiatric patients. These people are entitled to their space and privacy. Tourists need to stop entering the hospital grounds and hassling the kangaroo residents. This picture shows a very heat stressed roo that tourists nearly killed on the hot weekend. Enough already, the hospital is not a tourist attraction! |
| If you bring some carrots (in little pieces is better) for the kangaroos, they are very friendly with you! | While it is nice to experience Australian wildlife, this is not a tourist area nor is it a picnic area. This is a mental health facility, people live here. This is also the site for forensic mental health housing, look it up if you do not know the term. The kangaroos here are wild, they are not tame. Do not feed the roos carrots or any other foods, it makes them sick and aggressive. Getting too close to their young will also cause you problems. There are no public toilets or shops and water is not available at this location. Please respect the land and animals when you visit Australia, kangaroos are wild and will attack you if they feel threatened or frightened (especially the male kangaroos). |
| We went here to have a picnic and see some wild kangaroos and see some we did! Wouldn't advise eating around them as they will try and take your food and there is roo poo everywhere but if you drive further down the road past the hospital, there's nice little picnic tables literally at the water's edge. | It's a hospital and the patients don't need busloads of people arriving. It's a place for them to rest. They can't rest with everyone hanging around. Some people are just plain ignorant and self-centred. |
| I was very excited to see wild kangaroos when I moved to Sydney, tried couple of places but no luck, so my friend suggested to visit Morisset Park, it was a really fantastic experience to see really wild but very friendly kangaroos. | |
| The unique attraction of this location is the fact that wild free-range kangaroos are happy to be very close to people in many locations in this area. There are no fences and no admission fees. | |
| A must-see if you're visiting. Herds of kangaroos, they come up close, you can feed them, even touch them, kid friendly. | |

posed to tourists, especially with the animals being habituated to receiving food. The issue of unsupervised kangaroo tourism in Morisset reached a peak in political and media attention in May 2018 following numerous reports of tourist injuries inflicted by kangaroos (Gregory 2018; Millington and Farquhar 2018). The injuries reported included scratches to the face and arms requiring stitches, and a gash to the abdomen of one man who was subsequently taken away by ambulance. These incidents were widely reported by national and overseas media outlets (e.g., Wang 2018). Sensational headlines—'Carrot-addicted kangaroos hopping mad at tourists' (Channel News Asia 2018) and 'Kangaroos are viciously attacking tourists as visitors ignore authorities' warnings about feeding the animals' (Ziebell 2018)—were published, portraying the animals as being out of control. One tourist shuttle operator provided images of incidents, including one where an adult kangaroo can be seen with its front paw on a man's arm and its feet kicked up to the top of the man's right thigh. Other images published by the media gave the impression of people being attacked. A particular case in point was one photograph taken from a Facebook page showing an adult male kangaroo leaning against a man with one front paw on the man's face. The proximity of the kangaroo's claws to the man's face strikes alarm in many viewers' minds. However, the photograph also shows part of the man's arm raised, which is likely holding food that the kangaroo is being tempted with, but temporarily deprived of, in order to elicit a close encounter.

**Management interventions**

In November 2013, the Hunter New England Local Health District issued a public warning to dissuade tourists from visiting the hospital estate (Crawford 2013). At the time, Lake Macquarie independent councillor Barry Johnston, a local resident for over 40 years, criticised the warning, saying:

> People have been going there to have picnics since I can remember. It's great that tourists are coming to the hospital to see the kangaroos. Are we such a nanny state that we don't want anyone to ever risk getting hurt? You can protect people too much. (Crawford 2013).

His comments in support of the hospital estate being a local tourist attraction reflected some of the perspectives expressed on social media and travel websites (Table 3) but were strongly contested by others.

In an effort to curb tourists feeding the kangaroos and interacting with them inappropriately, the Hunter New England Local Health District erected signage to warn tourists. The two key messages portrayed were that feeding kangaroos is harmful to their health and that kangaroos are wild animals that may cause injury. Despite media outlets publishing photographs of these signs, numerous stakeholders continued to witness food provisioning by tourists.

In an address to the NSW parliament on 1 May 2018, the Member for Lake Macquarie, Greg Piper, said:

> That joey has left the pouch, so to speak, and the only thing we can do is to educate people about the dangers and find a way of managing the situation, not just for the safety of visitors and the hospital's residents, but also for the kangaroos themselves. (Gregory 2018).

The address highlighted the difficulties of controlling the situation, with the popularity of the site being inflated by user-generated content on websites.

Following increased scrutiny by local and international media outlets, a working group was formed with representation from the Hunter New England Local Health District, Royal Society for the Prevention of Cruelty to Animals (RSPCA), NSW Wildlife Council and NSW NPWS, as well as the Member for Lake Macquarie. The working group discussed options for management, which resulted in the announcement on 27 November 2018 that public access to the hospital estate would be restricted. In a media release, the Chief Executive of the Hunter New England Local Health District (2018) urged tour operators to cease marketing the site as a tourist attraction. The security upgrade was planned for March 2019.

**Deliberate harming of kangaroos**

In different mammalian taxa, animals conditioned to human presence have been found to have an increased probability of sustaining anthropogenic injuries (Benn and Herrero 2002; Christiansen *et al.* 2016). This was possibly observed on the hospital estate. Habituated kangaroos are more approachable and, therefore, more susceptible to malicious harm. Numerous cases of members of the public using four-wheel drive vehicles to chase and kill kangaroos occurred at the site. Common knowledge of the site potentially contributed to kangaroos on the hospital estate being targeted.

One media article in June 2008 reported two separate attacks that resulted in a total of 13 adult kangaroos being killed, others injured, and three joeys left orphaned (Cuneo 2008, 2009). The oldest joey weighed 2.4 kg at the time of the attack and was the only joey that was able to be successfully hand-reared and released. The repeat of such incidents in 2012 prompted the Hunter New England Health Service to begin to close the hospital estate at night (Gordon 2014). However, wildlife carers monitoring the entrance to the site alleged that some people continued to scale the fence to undertake other attacks on foot (Gordon 2014).

There have also been at least three archery attacks on kangaroos on the hospital estate. On 12 August 2015, hospital staff contacted local wildlife carers to attend to a female kangaroo with a sports arrow embedded in its chest (Kelly 2015). The kangaroo had both a pouch-dependent joey and a free-ranging joey and was unable to lie down due to the position of the arrow. Despite its injuries, the kangaroo was too mobile for wildlife carers to capture, and additional assistance was sought from the RSPCA the following morning. On 11 June 2017, another kangaroo was found with an arrow in its abdomen (Carr 2017). In both these cases, the injuries required the animals to be euthanised.

Following the announcement of restricted access, there was one further archery attack. On 16 December 2018, a female kangaroo was

discovered with a crossbow arrow protruding from the face between the muzzle and right eye (Moloney and Brown 2018). The arrow had been shot from behind, piercing the back of the head. The maimed kangaroo was first seen by a security guard who alerted wildlife carers.

**Discussion**

With kangaroos common in many urban areas (Coulson *et al.* 2014), human interactions with kangaroos will continue. In particular, the status of the kangaroo as a cultural icon is likely to drive demand for tourist experiences with kangaroos. There are numerous places where kangaroo tourism occurs with minimal issues, including national parks and camping areas (OEH 2018; Tourism Australia 2018). The issues on the Morisset Hospital estate represented a somewhat unique situation in that tourists were drawn in numbers, which was contrary to the purpose of the site as a psychiatric hospital. This case study highlights how recognising and addressing human perspectives and motives is a fundamental part of wildlife management (Davies *et al.* 2004); in this case, more so than managing the animals themselves. In a study of kangaroo reactions to tourist approaches, Wolf and Croft (2010) found that approach angles had important influence on kangaroo disturbance. Their study recommended that managers provide easy-to-follow instructions to tourists on how to best minimise disturbance in their approaches, which would, in effect, lead to longer-lasting and closer observations. However, this is difficult to achieve at sites like the Morisset Hospital estate where the primary purpose of the site is not wildlife tourism.

The insatiable desire for close encounters will likely see the practice of feeding wild kangaroos continue. There are now numerous studies showing the potential effects of food provisioning on wildlife, including increased rates of injuries (Christiansen *et al.* 2016), malnutrition (Murray *et al.* 2016) and increased intra- and interspecific aggression (Orams 2002). A recent review of food provisioning recommended the adoption of feeding practices that validate the nutritional appropriateness of food for the target species, and provide food at lower densities within short and unpredictable time periods and at varying places to prevent animals aggregating (Murray *et al.* 2016). Such practices can be achieved where provisioning occurs as a structured program. However, again, it is difficult to achieve this when wildlife tourism is unsupervised, especially where tourists are drawn to a single location.

The practice of using wildlife experiences to drive tourism to regional areas is not new (Stoeckl *et al.* 2005). The Entrance, a coastal suburb less than 35 km south of Morisset, has long been branded 'The Pelican Capital of Australia'. Since 1979, Australian Pelicans *Pelecanus conspicillatus* have been offered fish daily. This has grown into a major attraction that takes place daily on a specially built feeding platform. However, a key distinction between the pelican feeding at The Entrance and the kangaroo tourism in Morisset is that the pelican feeding is managed and supervised by staff and volunteers and covered by the necessary legislative approvals. In contrast, kangaroo tourism in Morisset was unsupervised and therefore lacking any management framework.

Similarly, the Western Australian town of Monkey Mia is well-known for its bottlenose dolphins *Tursiops* spp. habituated to interacting with tourists and receiving food since the 1960s (Smith *et al.* 2008). The regional economic dependence of these dolphin experiences has been studied through visitor surveys, showing a severe anticipated decline in expenditure and time spent in Monkey Mia if the dolphins were not present (Stoeckl *et al.* 2005). Similarly, the dolphin experiences provide opportunities for both the regional economy and public education (Blewitt 2008). However, some disadvantages have also been noted, such as people being injured from bites and forceful contact from dolphins and reduced calf survivorship in provisioned dolphins compared to wild-feeding dolphins (Wilson 1994). These negative impacts have improved since the introduction of changes to feeding strategies (Smith *et al.* 2006), which demonstrates the importance of supervision and management controls in tourism activities involving physical contact with wildlife. Such mechanisms were not possible for kangaroo tourism on the Morisset Hospital estate; thus the management of the issue eventually shifted towards revoking public access to the site.

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# Field Guide to the Frogs of Australia

by Michael Tyler and Frank Knight

Publisher: *CSIRO Publishing, Clayton South, Victoria 3169. Second Edition, 2020. 208 pages, paperback, colour photographs and distribution maps, colour and black and white illustrations. ISBN: 9781486312450. RRP $49.99.*

If you seek a guide to Australian frogs, you're not left wanting for choice these days. Numerous books on this subject range from 'naturalist' through 'photographic' guides to the remarkable tome of Anstis's *Tadpoles and Frogs of Australia*. Need a clinical description of all Australian frog species? Cogger's *Reptiles and Amphibians of Australia* is the go. Want to access just about all that is known about Aussie tadpoles? Grab Anstis's book. Want a guide in your backpack in case you encounter a frog during a hike? Well, you have a few choices but, unless you want a painful walk, I'd leave the massive books by Anstis and Cogger at home!

This brings us to the second edition of Michael Tyler and Frank Knight's *Field Guide to the Frogs of Australia*. Sadly, Professor Tyler is no longer with us. But, as a member of what I consider a golden era of research on Australian frogs (late 1950s into the 21st century), Tyler's contribution to our understanding of frog biology and conservation is enormous; this book is part of his wonderful legacy. Tyler approached his craft with élan, and a glint in his eye! Thankfully, his personality shines through in this book—consider this gem:

> A lady who reviewed the first edition of this book wrote that she would not recommend it, because I had not adopted the common name that she used for a particular species. Hopefully I will be excused for not wearing sackcloth and ashes (p. 2).

In what ways is this book distinct? Or, of perhaps more interest when choosing between all these books, what are the strengths of Tyler and Knight's book? This is a true field guide–its physical size makes it attractive for field use: it is 230 × 148 mm and just over 200 pages, ideal to keep in a vehicle glovebox or a daypack. It also seems robust; the covers are flexible with a plasticky feel, and I expect they'd last longer than the thin cardboard covers of many similarly-themed books.

There are updated accounts for all 248 native species known at the time of writing, including 18 described since the first edition (2011). The infamous Cane Toad, along with nine other non-native species, is also profiled. Species' accounts detail size, status, distribution, habitat, behaviour, advertisement call, and similar species. Distributions are illustrated on a necessarily small map of Australia. To keep the book small and light, information for each species is brief, and not every species is illustrated; for example, the Victorian species *Crinia signifera* and *C. parinsignifera* are physically all but identical, so the latter is not depicted.

The chapters preceding species accounts are succinct, but with enough relevant information. The introduction covers common and Latin names, as well as 'stowaway' frogs. Families and genera are detailed. The biology chapter covers key elements of anuran biology and morphology, as well as declines and conservation status, followed by a page describing habitats (plus three pages of photographs of habitats—the only photographs in the book). The species accounts are followed by a checklist, glossary, and reference list.

One thing that stands out is that, instead of using photographs of frogs, the species are illustrated by Knight's paintings. And what paintings they are! Each is not only technically accurate in form, proportions and colour, it is also beautiful. Knight, having previously painted Australian mammals (Menkhorst and Knight 2001), has done a masterful job. This use of artwork rather than photographs, so common in natural history books and field guides a century ago, is also seen in *The Australian Bird Guide* (Menkhorst *et al.* 2017). When done to Knight's standard, paintings are not inferior to photographs. One benefit is that closely-related species can be depicted in the same pose, emphasising similarities and differences 'on a level playing field'.

One thing I almost unconsciously look for in good books is some surprise; an inclusion that teaches me something new. In this case I learned that frog skin glands can contain antiviral agents. Considering how a virus has changed our lives in the last couple of years, this fact might appeal to those who need an anthropocentric reason to conserve amphibians.

I am a fan of regional/state fauna guides, because, by covering only local species, the process of identification is easier. But, if you require a robust frog field guide useful throughout Australia, I recommend this book.

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